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Experimental modal and static tests on a rack by Bassocontinuo - Reference line

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Summary

Present document resumes the results obtained during the modal and static tests performed by Vicoter on one rack manufactured by Bassocontinuo belonging to the Reference line.



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1. Introduction

Vicoter tested one rack manufactured by Bassocontinuo which belongs to the Reference line (Figure 1). Following tests are performed:

1. Modal analysis.
2. Static test under compression.

The purpose of the tests is twofold. From a dynamic point of view, Vicoter characterizes the behaviour of the rack up to the maximum observable frequency by measuring the resonance frequencies, the damping and the modal shapes. Tests are performed both in unloaded configuration and loading each shelf with 28 kg.

Form the static point of view, each shelf of the rack is loaded progressively to a maximum load of 70 kg and the load vs. shortening curves are recorded.

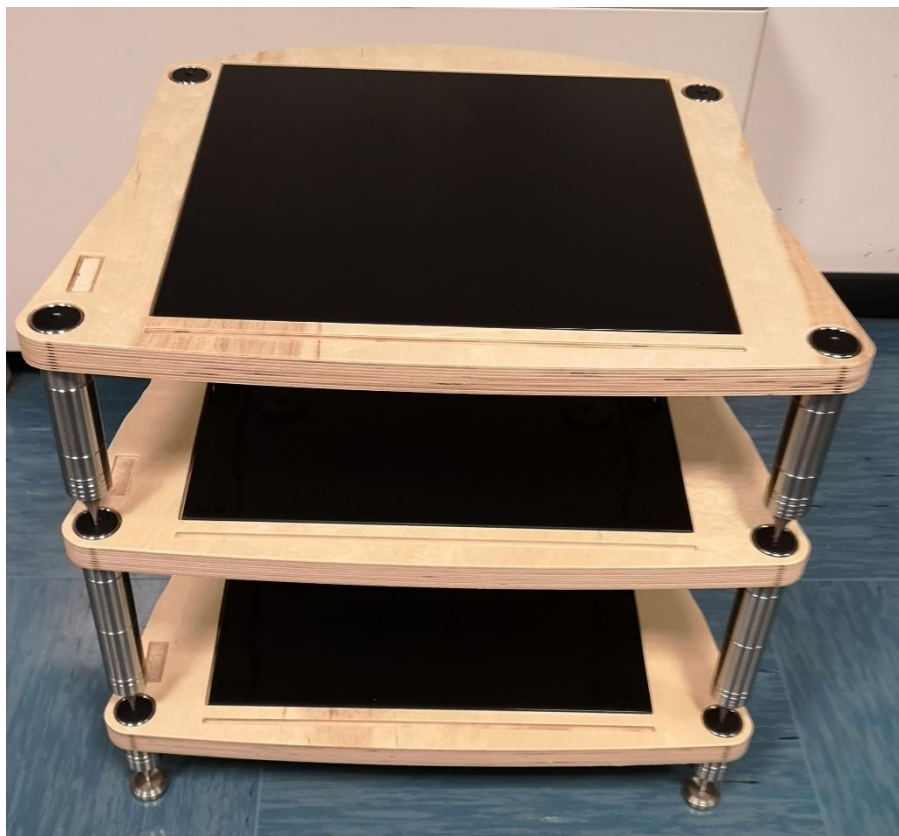


Figure 1. Reference line rack.

2. Modal analysis

2.1. Experimental setup

Modal tests are performed with the following instrumentation:

- 1 SCADAS 316 front-end for signal conditioning and acquisition.
- 15 PCB 333B32 uniaxial accelerometers, bandwidth from 0.5 Hz to 3 kHz and full-scale equal to 50 g.
- 5 PCB 356B08 triaxial accelerometers, bandwidth from 0.5 Hz to 5 kHz and full-scale equal to 50 g.
- 4 PCB 356A15 triaxial accelerometers, bandwidth from 2 Hz to 5 kHz and full-scale equal to 50 g.
- 1 PCB 356A02 triaxial accelerometer, bandwidth from 1 Hz to 5 kHz and full-scale equal to 500 g.
- 1 instrumented hammer with a PCB 086B03 load cell, to excite the structure. The hammer is equipped with a soft tip able to excite the band up to 2048 Hz.
- Software LMS-TestLab, release 17, for data-processing.

The rack is instrumented in 15 points. On each point, a tri-axial acceleration measurement is carried out. Corresponding wireframe is shown in Figure 2.

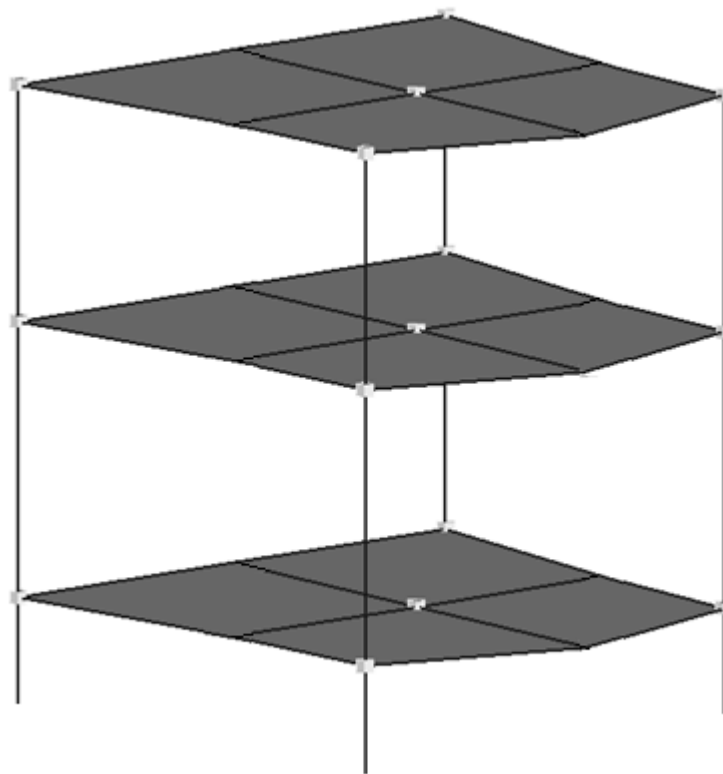


Figure 2. Rack wireframe for modal tests.

Rack during the tests, as well as some particulars of sensors installation, is presented in Figure 3 and in Figure 4.



Figure 3. Reference line rack during modal tests.

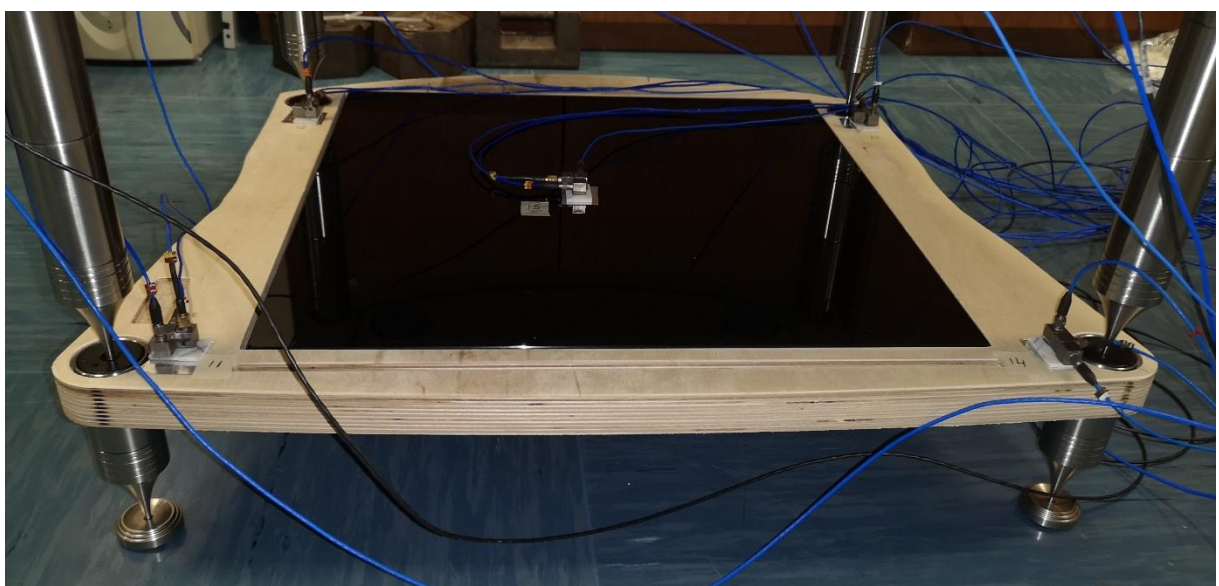


Figure 4. Reference line rack during modal tests – Sensor installation on the bottom shelf.

Following dynamic tests are performed:

1. Tests on unloaded rack.
2. Tests on rack loaded up to 112 kg.

2.2. Results

Modal tests on unloaded rack

These tests are performed on the rack without any additional weight, as shown in Figure 5.

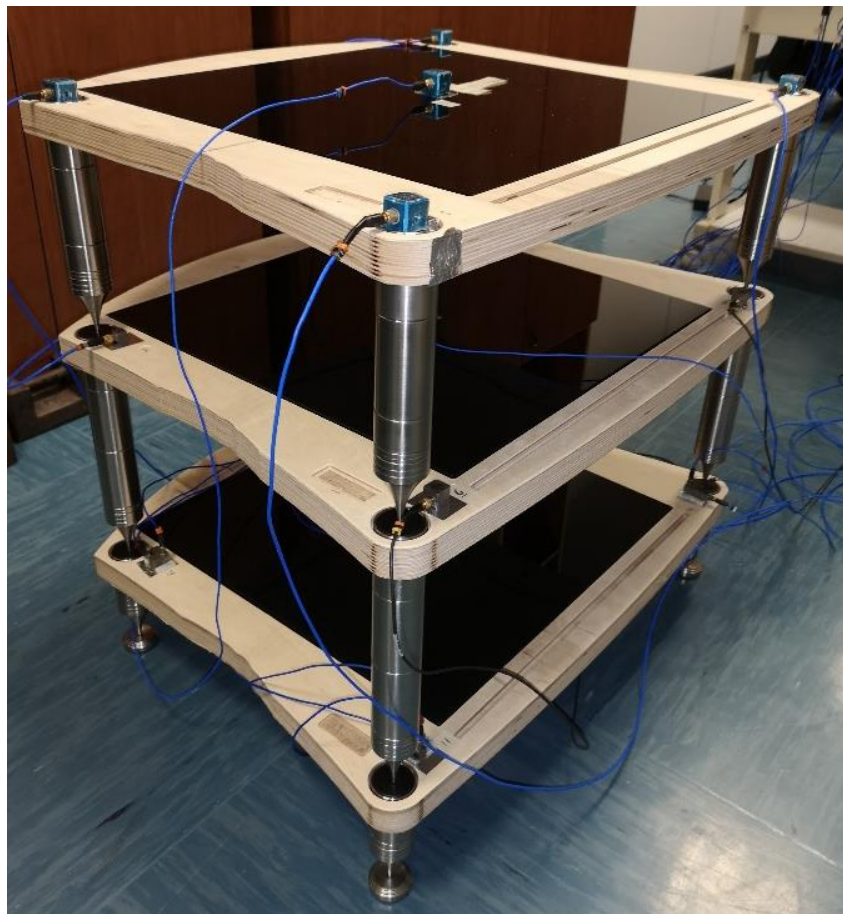


Figure 5. Unloaded rack during modal tests.

Modal frequencies and corresponding damping are resumed in Table 1. Please note that the maximum observable frequency is equal to 417 Hz.

Mode ID	Reference line	
	Frequency (Hz)	Damping (%)
1	8.913	4.10
2	9.267	4.17
3	12.105	4.06
4	29.700	4.77
5	31.855	3.08
6	42.494	6.04
7	45.590	8.04
8	46.837	9.79
9	64.364	7.00
10	68.155	5.74
11	93.657	2.06
12	228.429	2.57
13	268.613	3.15
14	335.596	3.32
15	416.930	3.76

Table 1. Resonance frequencies and damping measured on the unloaded rack.

Modal shapes of the first six modes are reported in the figures from Figure 6 to Figure 11.

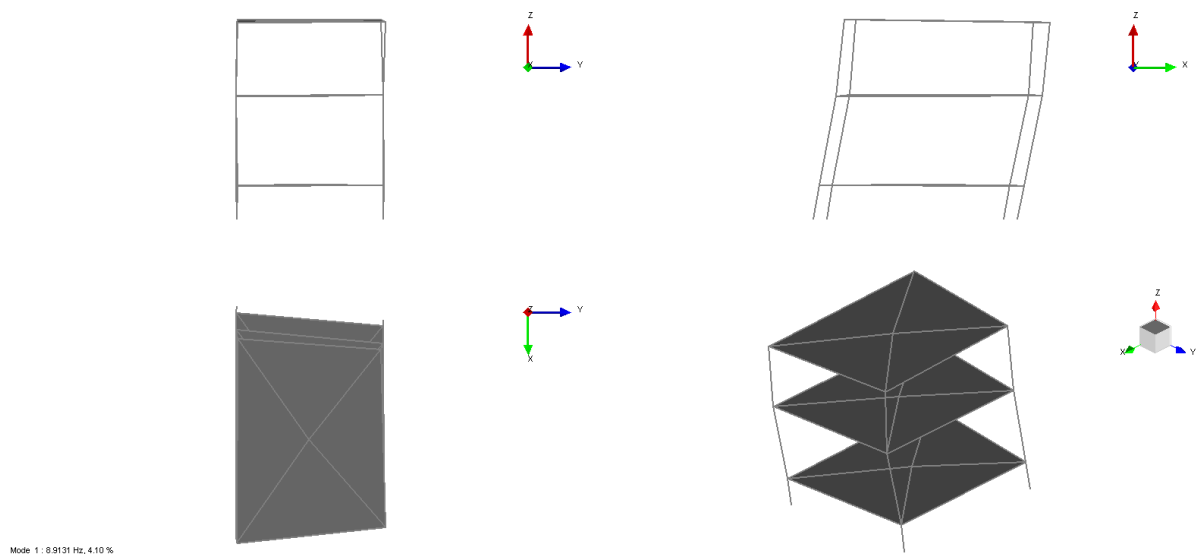


Figure 6. Reference line – Mode 1 – Unloaded rack.

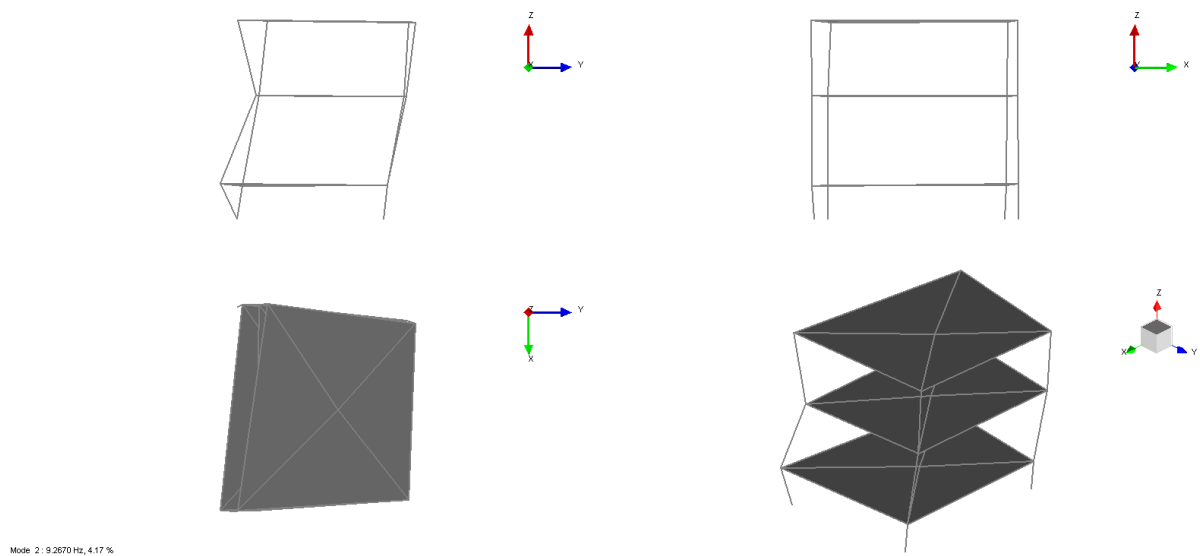


Figure 7. Reference line – Mode 2 – Unloaded rack.

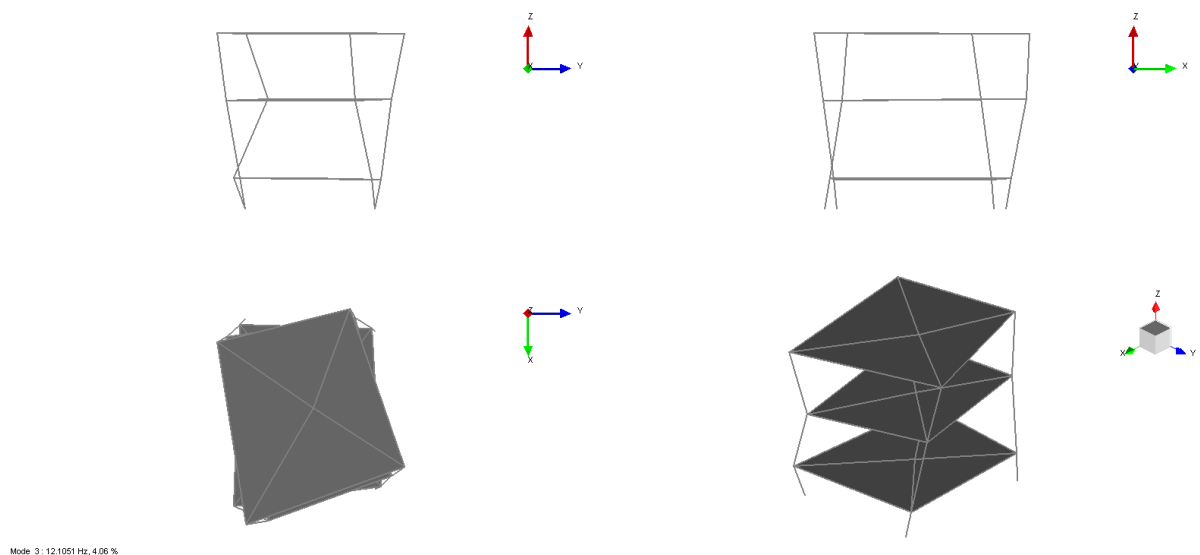


Figure 8. Reference line – Mode 3 – Unloaded rack.

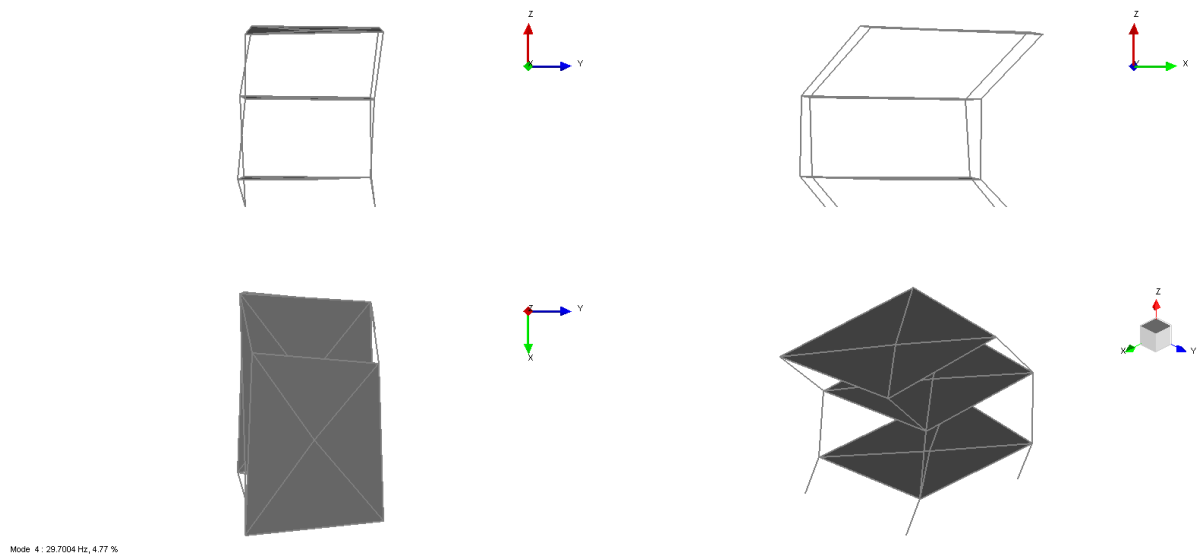


Figure 9. Reference line – Mode 4 – Unloaded rack.

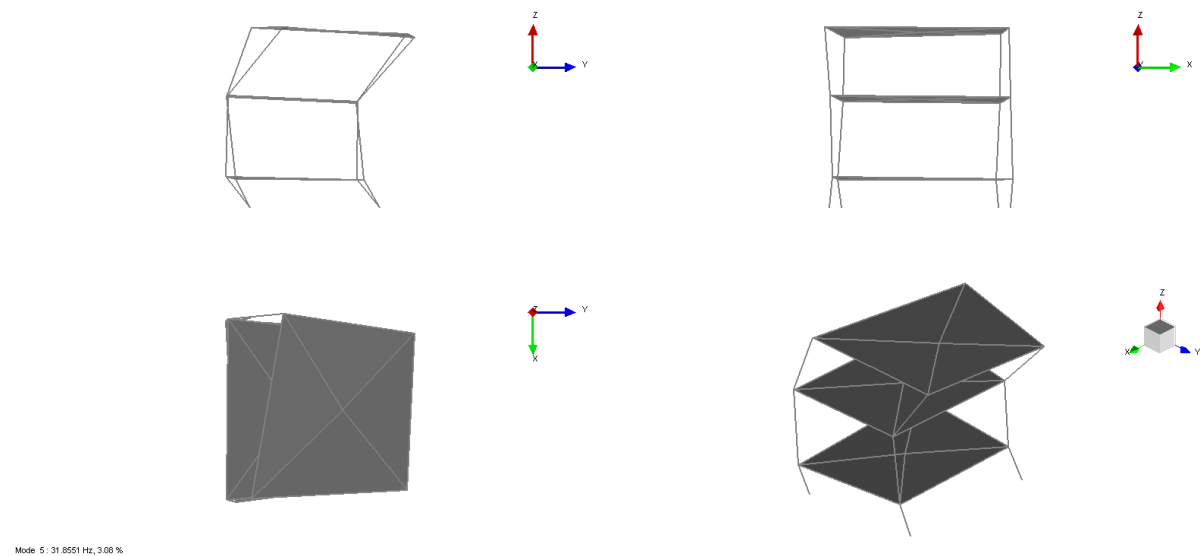


Figure 10. Reference line – Mode 5 – Unloaded rack.

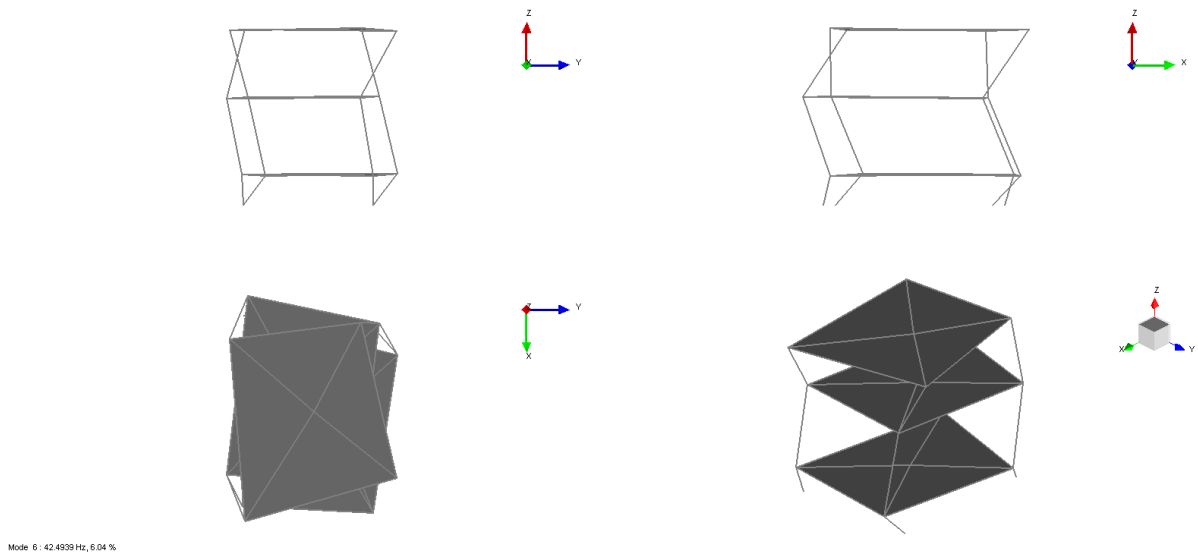


Figure 11. Reference line – Mode 6 – Unloaded rack.

Modal tests on loaded rack

These tests are performed loading each shelf of the rack with 28 kg. Modal frequencies and corresponding damping are resumed in Table 2. Please note that the maximum observable frequency is equal to 249 Hz.

Mode ID	Reference line	
	Frequency (Hz)	Damping (%)
1	5.371	3.89
2	5.566	4.20
3	9.216	4.43
4	17.363	3.60
5	18.158	4.25
6	27.329	5.46
7	30.901	4.68
8	37.471	3.57
9	40.080	4.93
10	51.575	4.74
11	124.273	7.52
12	248.760	1.89

Table 2. Resonance frequencies and damping measured on the loaded rack.

Modal shapes of the first six modes are reported in the figures from Figure 12 to Figure 17.

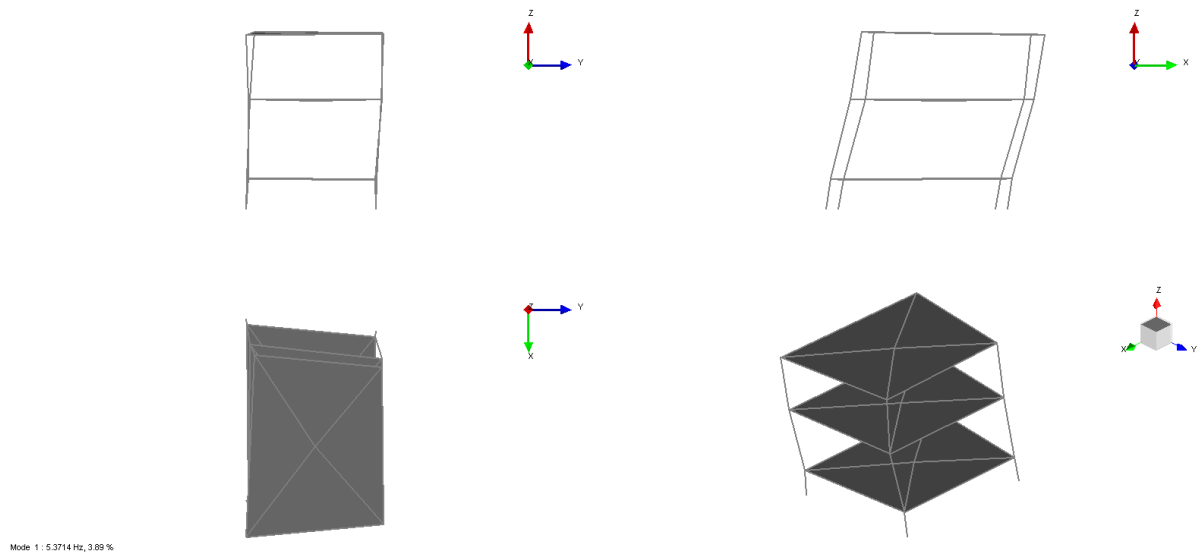


Figure 12. Reference line – Mode 1 – Loaded rack.

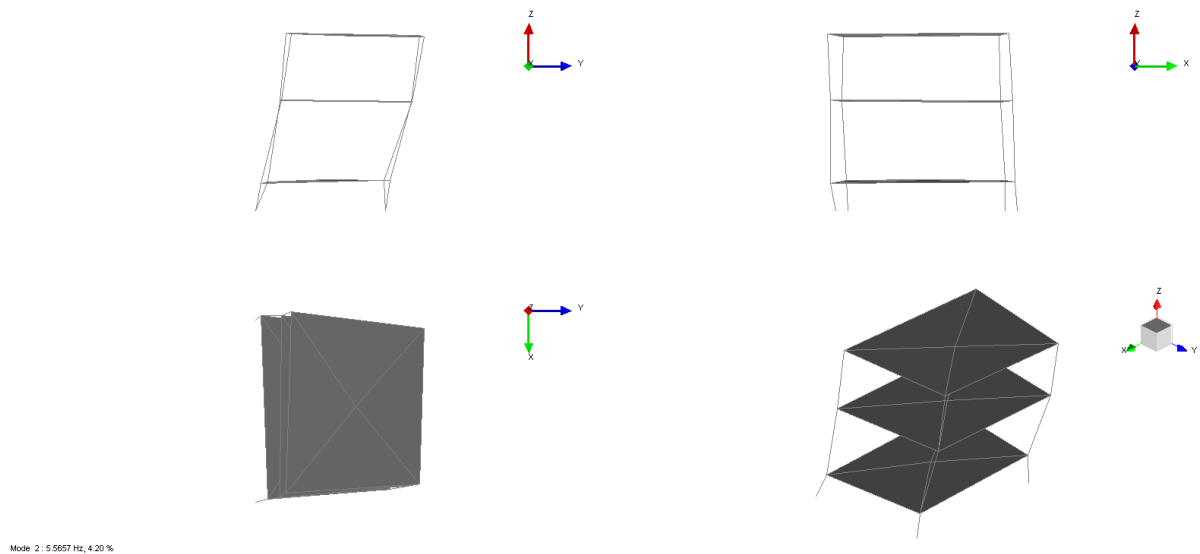


Figure 13. Reference line – Mode 2 – Loaded rack.

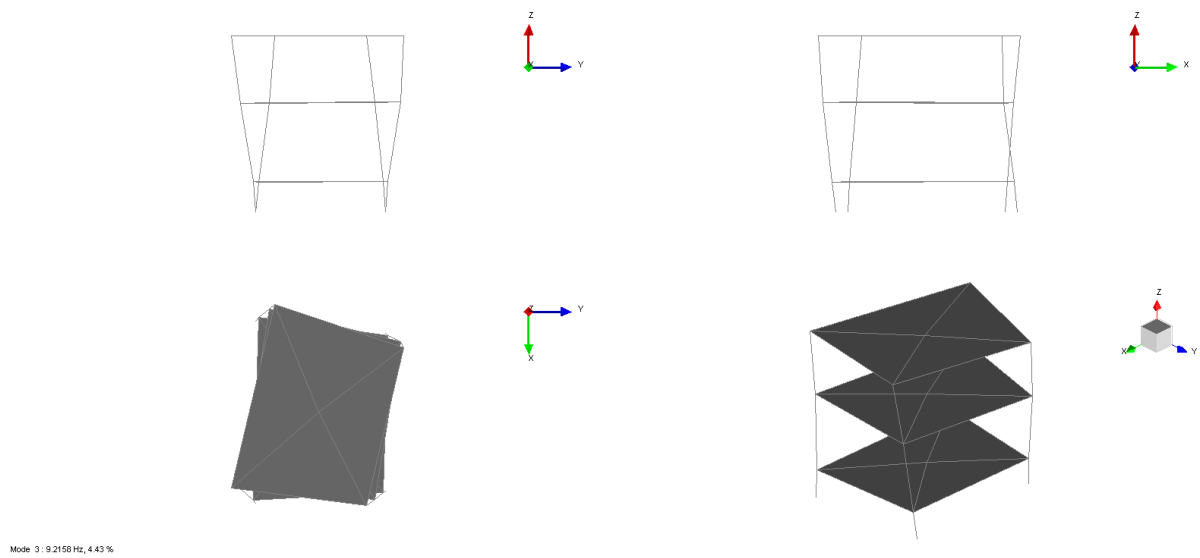


Figure 14. Reference line – Mode 3 – Loaded rack.

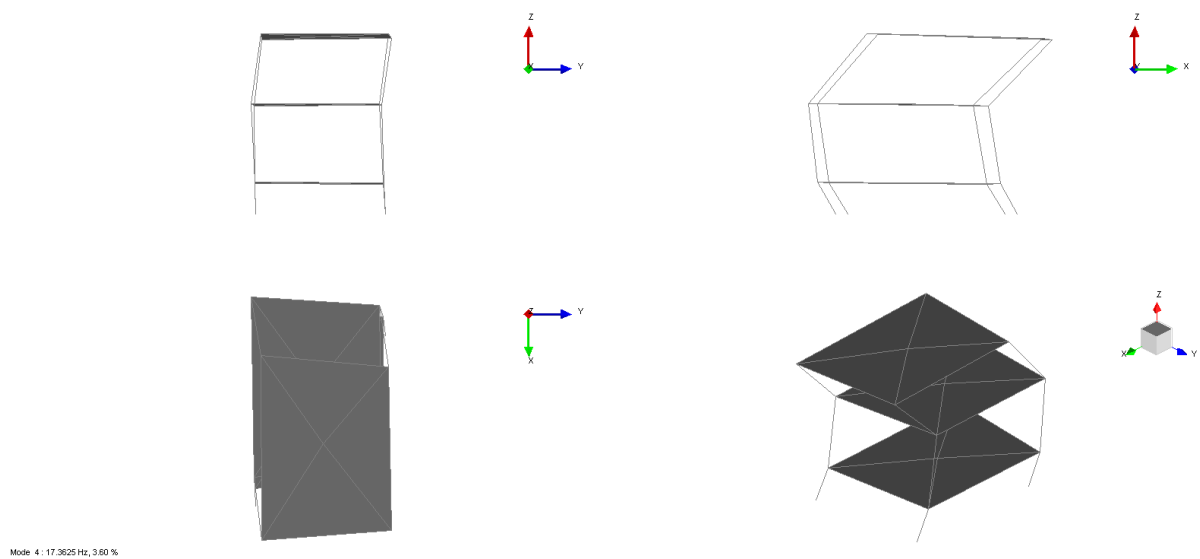


Figure 15. Reference line – Mode 4 – Loaded rack.

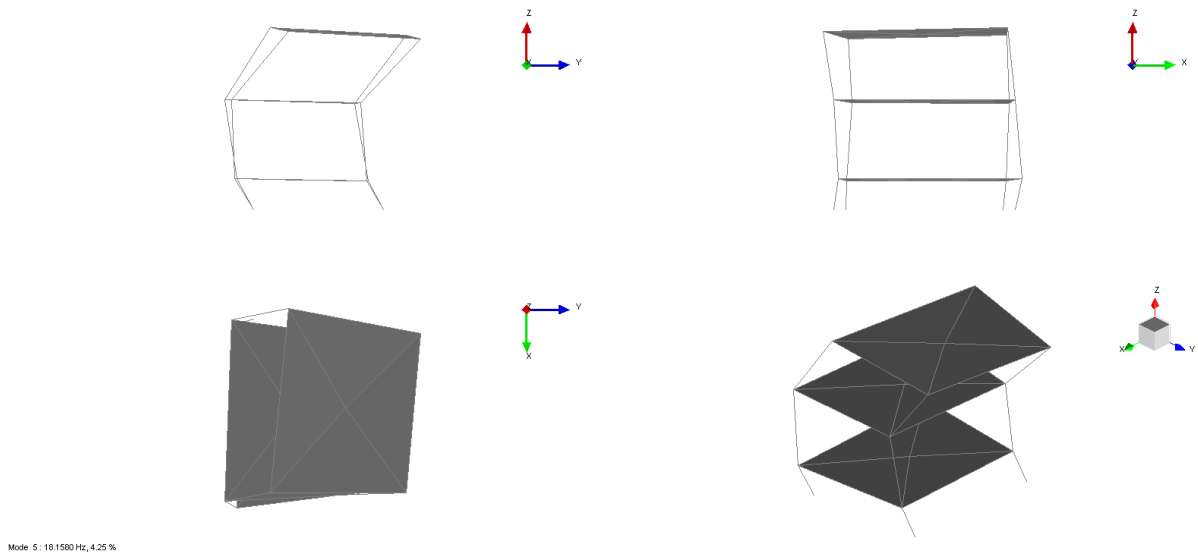


Figure 16. Reference line – Mode 5 – Loaded rack.

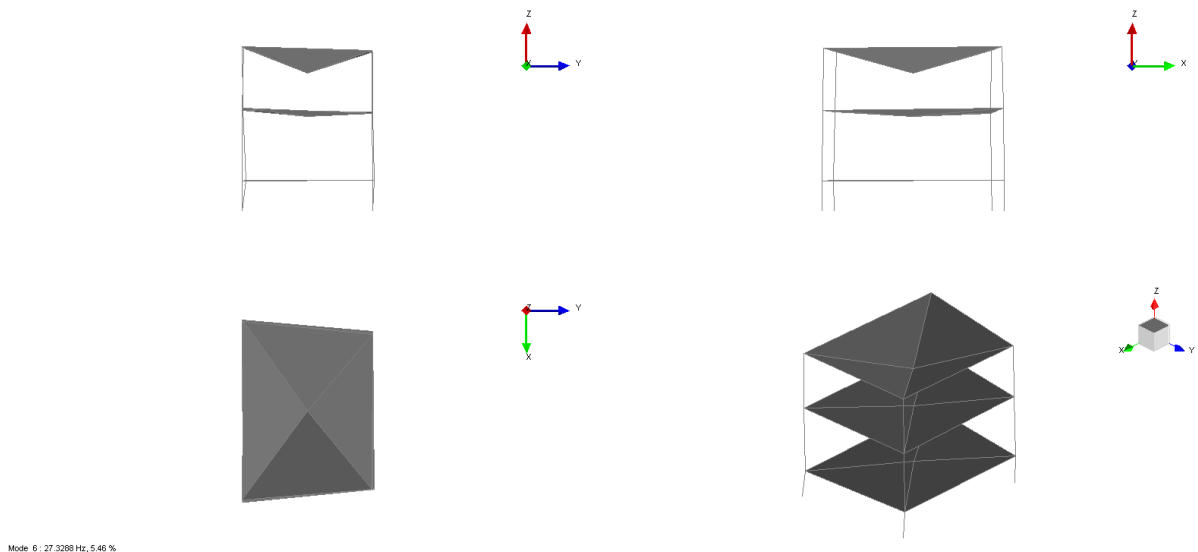


Figure 17. Reference line – Mode 6 – Loaded rack.

3. Static tests

3.1. Experimental setup

Two static tests are performed:

Test 1. Top shelf loading.

Test 2. Middle shelf loading.

Both tests are performed using calibrated weights to load the structure from 0 kg to 70 kg and vice-versa and the load vs. shortening curves are recorded.

Two Nippon Automation LAS-8010V laser sensors are used, with measuring range equal to $100 \text{ mm} \pm 40 \text{ mm}$, resolution of $50 \text{ }\mu\text{m}$ and response time of 50 ms.

In the test 1 it is decided to measure both the shortening of the central point of the loaded shelf and the shortening of one column; in test 2 only the shortening of the of the central point of the loaded shelf is measured.

Figures from Figure 18 to Figure 20 show pictures of the rack during static tests.



Figure 18. Reference line during static tests – Top shelf loading.

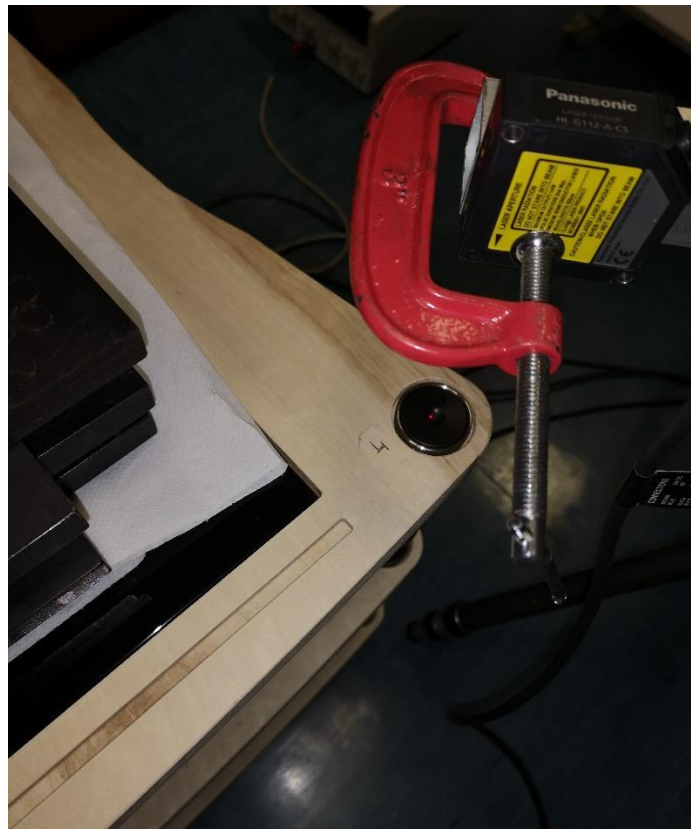


Figure 19. Reference line during static tests – Top shelf loading – Measurement point 2.



Figure 20. Reference line during static tests – Middle shelf loading.

3.2. Results

Obtained results are presented in the graphs from Figure 21 to Figure 23 and summarized in Table 3.

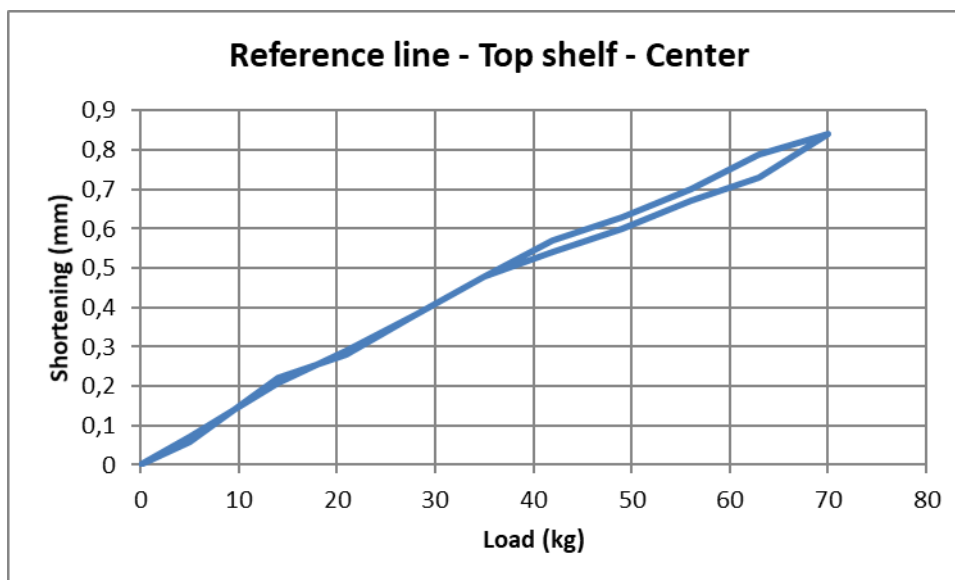


Figure 21. Reference line, test 1 – Shortening of central point as function of applied load.

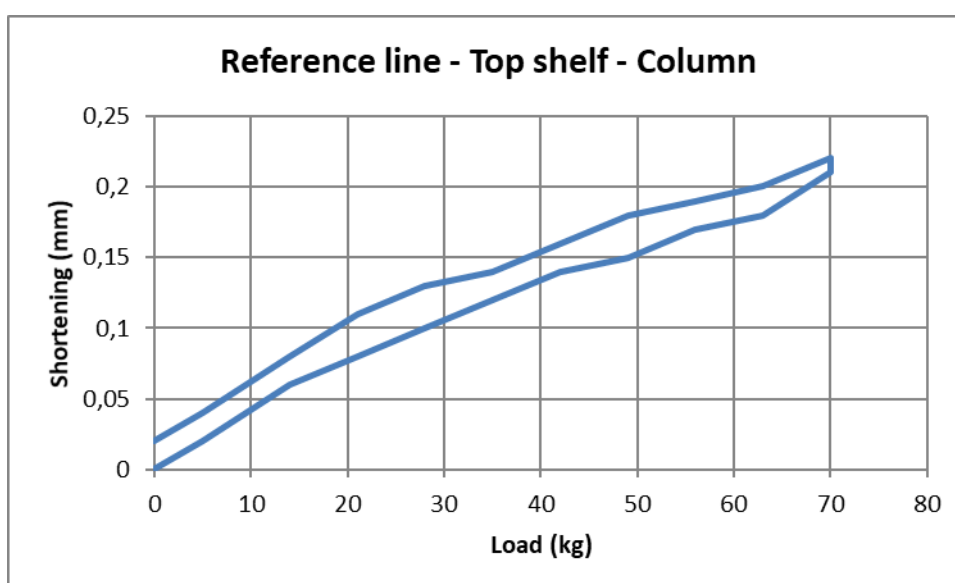


Figure 22. Reference line, test 1 – Shortening of corner point as function of applied load.

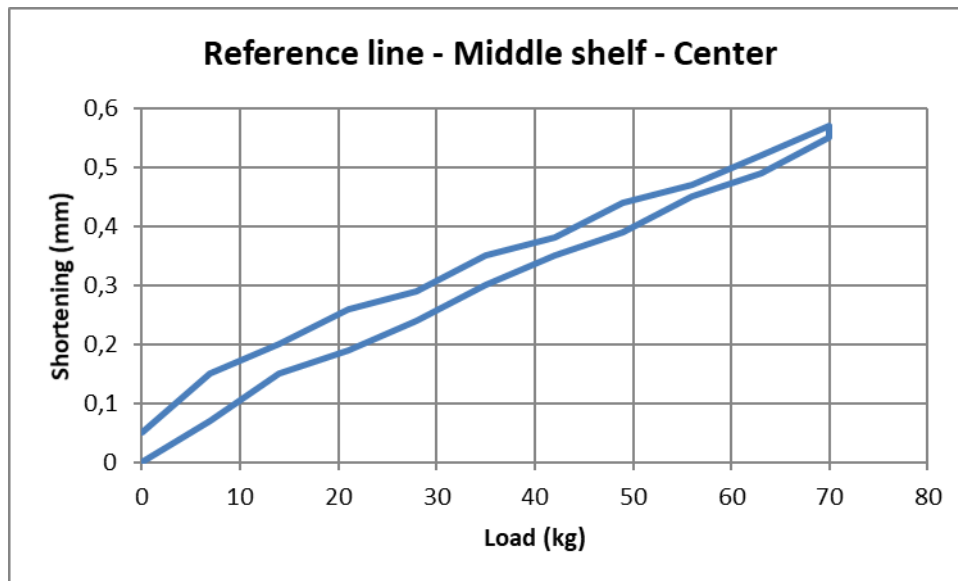


Figure 23. Reference line, test 2 – Shortening of central point as function of applied load.

Test type	Reference line		Measuring point
	Maximum load (kg)	Maximum shortening (mm)	
1	70	0.84	Centre of top shelf
1	70	0.21	Rack's corner
2	70	0.55	Centre of middle shelf

Table 3. Static test results.

4. Conclusions

The rack manufactured by Bassocontinuo and belonging to the Reference line has shown excellent performances both from a dynamic and a static point of view.

Indeed, Vicoter was able to clearly identify only the natural frequencies up to 417 Hz in the unloaded configuration and up to 249 Hz in the loaded configuration. This means that, in the largest part of the audible band (20 Hz - 20 kHz), the rack does not have accentuated modal peaks; therefore, it does not significantly amplify any disturbances arriving from the outside.

Furthermore, from a static point of view, the rack showed excellent strength. Indeed, when loaded with 70 kg on the single shelf, it presented a maximum shortening lower than 0.9 mm of the shelf itself and a shortening of the supporting columns of only 0.21 mm.

Finally, if compared to the Classic line of Bassocontinuo, the Reference line shows a notable improvement both in dynamic performance, with a damping almost doubled on each modal frequency, and in robustness, since the maximum shortening measured on the central shelf is 0.84 mm (1.22 mm for the Classic line).